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## Cosmology with EMSS Clusters of Galaxies

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**Abstract.** We use ASCA observations of the Extended Medium Sensitivity Survey sample of clusters of galaxies to construct the first  $z = 0.5 - 0.8$  cluster temperature function. This distant cluster temperature function, when compared to local  $z \sim 0$  and to a similar moderate redshift ( $z = 0.3 - 0.4$ ) temperature function strongly constrains the matter density of the universe. Best fits to the distributions of temperatures and redshifts of these cluster samples results in  $\Omega_M = 0.45 \pm 0.1$  if  $\Lambda = 0$  and  $\Omega = 0.27 \pm 0.1$  if  $\Lambda + \Omega_M = 1$ . The uncertainties are  $1\sigma$  statistical. We examine the systematics of our approach and find that systematics, stemming mainly from model assumptions and not measurement errors, are about the same size as the statistical uncertainty  $\pm 0.1$ . In this poster proceedings, we clarify the issue of  $\sigma_8$  as reported in our paper Donahue & Voit (1999), since this was a matter of discussion at the meeting.

The main results and new data described in our poster are reported by us in two papers [1],[2] following previously described techniques [3],[4]. The data are new ASCA observations of the most distant EMSS clusters of galaxies, increasing the power of tests constraining  $\Omega_M$  with comparisons to cluster evolution models normalized to the current epoch with local cluster observations.

An executive statement of our results is that we have measured the mean temperatures of the intracluster media (ICM) of five EMSS clusters with  $z = 0.55 - 0.83$ . In combination with the work of Henry[4] on an intermediate redshift sample of nine EMSS clusters ( $z = 0.3 - 0.4$ ) and local samples of clusters of galaxies [5],[6], we have constructed temperature functions for each sample and find that very little evolution in the temperature function has occurred since  $z \sim 0.8$ , consistent with lack of evolution in the cluster LF [7], [8].

If the mean temperature of the ICM reflects the depth of the potential well, that is, that the mass-temperature ( $M - T$ ) relation of clusters is robust, then the evolution of the temperature function reflects the evolution of the cluster mass function. We presented evidence that, as in low redshift samples, two mass estimators, the velocity dispersion and the ICM temperature, agree with each other in these massive high redshift clusters as well.

Theoretically, the  $M - T$  relationship also seems to be relatively robust, from the analysis of simulations, with a scatter of up to 20%, which we incorporate into our statistical analysis. [9] provide some additional analysis of this relation; the normalization and evolution of this relation are critical elements of models of the temperature function evolution[10].

We use maximum likelihood analysis to compare the predictions of the extended Press-Schechter model [11][12] to our data. We fit three parameters:  $\Omega_M$ ,

a local perturbation slope  $n$  (relevant between cluster temperature 3-12 keV) and a normalization  $\nu_{c0}$ , which is related to  $\sigma_8$  through a combination of  $\Omega_M$ ,  $n$ , and the assumed  $M - T$  relation. We do not directly fit  $\sigma_8$ , nor is it directly comparable to other measures of  $\sigma_8$  which may use different  $M - T$  relation and extrapolate with different  $n$ . The normalization  $\nu_{c0}$  is defined to be the significance, in sigma, of the fluctuation associated with a cluster of 5 keV, and is more directly measured from the high-temperature cluster temperature function. The  $\sigma_8$  reported[2] is the  $\sigma_8$  and accompanying uncertainty derived if  $\Omega_M$  is held constant at the best fit value and  $n$  and  $\nu_{c0}$  are allowed to vary, and the  $M - T$  relation[9] is assumed.

Further quantification and a deeper theoretical investigation of the systematics will be forthcoming in two publications[10],[13]. Our poster conclusions are summarized here: The two assumptions that make the most impact on the best-fit value of  $\Omega_M$  are the adoption of the low-redshift sample and the assumption that the Press-Schechter description works for the most massive clusters. Because hot clusters are so rare, the low-redshift sample is of limited size. The definition of such a sample makes a difference such that the adoption of the HEAO allskysample[6] yields a lower value of  $\Omega_M$  than does adopting a ROSAT-defined low-redshift sample[5]. We use the ROSAT sample as the standard sample. If we reduce the standard evolution of  $\nu$  by a factor  $(1+z)^{-0.125}$  [14], the best-fit  $\Omega_M$  increases to  $0.5^{+0.2}_{-0.05}$ . Other effects that we investigated but had less impact on the best fit  $\Omega_M$  were: any evolution of the luminosity-temperature relation (relevant to defining the sample volumes), inclusion or exclusion of the most extreme cluster MS1054-0321[15], changing the  $M - T$  relation (at least for  $\Omega_M > 0.3$ ) or its dispersion.

## References

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